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### PHYSICAL CHARACTERISTICS OF NOVICE AND EXPERIENCED WOMEN MARATHON RUNNERS

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#### ABSTRACT

The physiological and anthropometric characteristics of 23 non-elite women marathoners were studied. Ten of these women had never run a marathon before (novices) and 13 had run at least one marathon during the previous year (experienced). A comparison of characteristics of these two groups to each other and to elite women marathoners, as reported in the literature, disclosed no significant differences ( $p > 0.01$ ) among the groups in age, % body fat, body weight, height, lean body mass or HR max. Significant differences ( $p < 0.01$ ) were noted, however, in  $\text{VO}_2$  max (45.8, 51.8, 59.1  $\text{ml.kg}^{-1}\text{min}^{-1}$ ),  $\text{V}_{\text{E}}$  max (76.3, 94.7, 108.9  $\text{L.min}^{-1}$ ), and years of training (0.54, 2.06, 4.55 years) with the novice runners having the smallest values, the experienced runners having the next larger values, and the elite runners having the largest values. For our subjects, estimated percentage of body fat did not correlate with finish time, but  $\text{VO}_2$  max and finish time were significantly related ( $r = -0.72, p < 0.01$ ). This suggests that women marathon runners are similar in anthropometric measurements, and that improved performance is associated with higher aerobic capacity and years of training rather than with body dimensions.

Key words: Aerobic capacity, Body composition, Marathon runners.

#### INTRODUCTION

Marathon running is a relatively new event for women. While in the early 1970's virtually no women ran in marathons (42.2 km), approximately 8,000 women completed marathon races throughout the world in 1979. Little is known about the anthropometric and physiological characteristics of women who run marathons.

After reviewing the literature, Wilmore and Brown (1974), and Wilmore, Brown et al (1977) drew similar conclusions regarding the body composition of elite women distance runners. When compared with other segments of the population, the women they studied were: (a) considerably leaner than the average non-active female, (b) among the leanest of the female athletes, (c) similar in relative body fat to the average sedentary male, and (d) fatter than the average male marathoner.

Women distance runners also appear to have high aerobic capacities. After comparing their women distance runners to women in other studies, Wilmore and Brown (1974), and Jordan (1977) agreed that women distance runners have higher aerobic capacities

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than sedentary women, and most other women athletes. After further comparisons, Wilmore and Brown (1974) reported that their subjects had higher  $\text{VO}_2$  max values than sedentary males, but lower  $\text{VO}_2$  max values than male distance runners.

Generalisations from the results of the studies cited to the majority of female marathon runners are limited. The subjects of these studies were not all marathoners. Wilmore and Brown (1974) considered distance competition as running in events of two miles (3.2 km) or longer; however, women who are competing in two mile events can hardly be considered marathon runners, despite the fact that their training mileage might be similar to that of the marathon runner. The failure of the authors to specify the distances run by their subjects limits generalisations of their data to women marathon runners.

Another limitation to generalisation is the use of elite women marathon runners. World-class and national-calibre women distance runners served as subjects in many of the studies to date. Just as the anthropometric and physiological characteristics of the women tested differ from sedentary women, they may also differ from the majority of women runners who participate in marathon events either to complete the distance or to better a personal record.

The purpose of the present study was to examine the physiological and anthropometric characteristics of novice and experienced non-elite women marathon runners. These women might be representative of the majority of women marathoners who complete marathons in longer than three hours. The physiological profiles of these females were compared with female elite distance runners, athletes, and sedentary women.

## METHODS

Ten novice women marathon runners (women who were training to run a marathon but had never attempted a marathon previously), and 13 experienced women marathoners (women who had run at least one marathon during the previous 13 months) served as subjects. These women ran 48-145 km (30 to 90 miles) a week in preparation for a marathon. Testing was completed in the Human Performance Research Laboratory on the University of Utah campus, at an altitude of 1310 metres. All subjects had resided and trained at this altitude for at least six weeks prior to the study. This time period was deemed necessary to insure adequate altitude acclimatisation (Dill, 1968). An informed consent was completed by all subjects prior to their participation in the study. In addition, subjects completed a questionnaire concerning their training for the marathon and past running experience.

Women who responded to our advertisement (which

had been placed at strategic locations around the university and the city requesting volunteers) and who fulfilled the prerequisites (marathon experience, running mileage, altitude acclimatisation) were selected as volunteer subjects. All subjects were Caucasians.

To assess maximal aerobic capacity, each subject performed a multi-stage progressive exercise test on a Quinton motor-driven treadmill using a modified Balke protocol (Balke and Ware, 1959). Treadmill speed was set at  $91.2 \text{ m} \cdot \text{min}^{-1}$ , and the slope was increased 1% each minute of the test until the subject indicated she could no longer continue or until signs or symptoms of intolerance were observed (ACSM, 1980). This particular treadmill protocol was chosen because previous reports (Falls and Humphrey, 1973; Moody, Kollias and Buskirk, 1969) demonstrated that women prefer this test over other treadmill tests of maximum aerobic capacity.

Respiratory parameters were measured using open-circuit, indirect-calorimetry techniques. The subjects breathed through a low-resistance Modified Otis-McKerrow valve connected to a Parkinson-Cowen CD-4 ventilation meter open to room air on the inhalation side, and a mixing chamber to Beckman OM-11 and LB-2 gas analysers to measure oxygen and carbon dioxide concentrations, respectively, on the exhalation side. These concentrations were recorded from digital readouts during the last ten seconds of each minute. The gas analysers were periodically calibrated with room air and with commercial gas mixtures of known concentrations. Heart rate (HR) was determined from ECG recordings made during the final 10 seconds of each minute on either a Cambridge VS4S single channel ECG or a Sanborn 7700 series multi-channel recorder. Ventilation volume was determined from a continuous recording of the ventilation meter output. Criteria for  $\text{VO}_2$  max included: HR near age predicted maximum, and  $\text{VO}_2$  increase of less than  $150 \text{ ml} \cdot \text{min}^{-1}$  or  $2.1 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$  despite an increase in workrate by an increase in treadmill slope (Shephard, Allen et al, 1968; Taylor, Buskirk et al, 1955). Although, data were available at each workrate, it was the intent of this study to compare maximum values of these women to those previously reported in the literature (Wilmore and Brown, 1974).

Tests were performed 7 to 11 days before a marathon, prior to the subject's run for the day, and at least two days after a training run of 30 km or longer in an attempt to reduce the possible contamination of the results from previous fatigue (Thompson, 1977). Following the marathon, a letter requesting finish times and containing the names of the subjects was sent to the race directors. The response of the race directors was considered as the subjects' finish time.

Skinfold measurement techniques were utilised to

estimate body composition. Since there were no equations available for use with highly trained women between the ages of 20 and 39 years, several equations were considered and measurements were made on two potential subjects. The method of Sloan, Burt and Blyth (1962) was selected; it appeared to be the best predictor for this sample, this equation gave the most reasonable values in the pilot study and had been used in a previous study of women marathon runners (Jordan, 1977). Two measurements were made with a Harpenden Calliper at each site; their average was utilised in equations to estimate body density. When measurements differed by more than 1%, a third measure was taken, and the mean of the closest two measurements was used as the representative value (Wilmore and Behnke, 1970).

The assessed characteristics of novice and experienced runners in the present study were compared to each other, and to the elite (national and international calibre) women distance runners studied by Wilmore and Brown (1974). Data were analysed for differences with a one-way analysis of variance using BMDP P1V statistical package programme. To locate differences, *t*-test for contrasts of group means were used ( $p < 0.05$ ). In *posteriori* tests, Pearson Product Moment Coefficients of Correlation were calculated for  $\dot{V}O_2$  max and finish time, and for estimated body fat and finish time for subjects in the present study.

## RESULTS

The results of testing are presented in Table I. Years of training,  $\dot{V}O_2$  max, and  $\dot{V}_E$  max were smaller ( $p < 0.01$ ) for the novice group than for the experienced or elite groups. These same variables were smaller for the experienced group than for the elite group ( $p < 0.01$ ). Thus, the novice runners had the smallest aerobic capacity and elite runners had the highest aerobic capacity. No differences ( $p > 0.05$ ) were detected among the three groups in HR max, age, or measures of body size and composition. The mean finish time for the novice group was 282.2 minutes (4 hours, 42 minutes), and it was 226.9 minutes (3 hours, 47 minutes) for the experienced group. The correlation between estimated percentage of body fat and finish time ( $r = -0.39$ ) for the pooled groups of this study was not significant ( $p > 0.05$ ). The correlation between body weight and finish time ( $r = 0.16$ ,  $p > 0.01$ ) was also not significant. A significant relationship ( $p < 0.01$ ) between  $\dot{V}O_2$  max and finish time ( $r = -0.72$ ) was disclosed, however.

## DISCUSSION

Although differences existed in  $\dot{V}O_2$  max among the three groups examined, the novice and experienced runners of the present study had high aerobic capacities (45.8 and 51.8 ml.kg<sup>-1</sup> min<sup>-1</sup>, respectively) when com-

TABLE I

Physical characteristics and training years of women distance runners. (Mean  $\pm$  SD)

Characteristic	Distance Runners		
	Novice marathon runners n = 10	Experienced marathon runners n = 13	Elite distance runners** n = 11
Age (yr)	29.6 $\pm$ 5.6	32.7 $\pm$ 4.1	32.4 $\pm$ 4.5
Height (cm)	164.0 $\pm$ 6.9	164.7 $\pm$ 4.9	169.4 $\pm$ 9.0
Body Weight (kg)	55.7 $\pm$ 8.0	57.0 $\pm$ 5.4	57.2 $\pm$ 6.7
Lean Body Weight (kg)	44.8 $\pm$ 6.2	47.7 $\pm$ 4.3	48.1 $\pm$ 3.5
Body Fat (%)	18.0 $\pm$ 2.9	16.3 $\pm$ 1.4	15.3 $\pm$ 8.1
$\dot{V}O_2$ max (ml.kg <sup>-1</sup> min <sup>-1</sup> )*	45.8 $\pm$ 4.9	51.8 $\pm$ 3.2	59.1 $\pm$ 6.6
$\dot{V}_E$ max (L.min <sup>-1</sup> )*	76.3 $\pm$ 10.2	94.7 $\pm$ 10.4	108.9 $\pm$ 8.6
HR max (b.min <sup>-1</sup> )	176.5 $\pm$ 4.6	181.8 $\pm$ 7.0	180.4 $\pm$ 8.9
Training (yr)*	0.54 $\pm$ 0.31	2.06 $\pm$ 1.16	4.55 $\pm$ 2.30

\* ( $p < 0.01$ ), novice < experienced < elite runners

\*\* data from Wilmore and Brown (1974)

pared to non-running women. The range of  $\dot{V}O_2$  max of 48.8 (Bransford and Howley, 1977) to 63.0 ml.kg<sup>-1</sup> min<sup>-1</sup> (Gregor and Kirkendall, 1978) measured from women distance runners were considerably greater than the 40 ml.kg<sup>-1</sup> min<sup>-1</sup> reported for the average women (Åstrand, 1960; Drinkwater, 1973). When women distance runners and sedentary female controls were studied in a single investigation, large differences in  $\dot{V}O_2$  max were noted between the two groups (Bransford and Howley, 1977; Drinkwater, Kupprat et al, 1977; Wilmore and Brown, 1974).

When compared to other female athletes, female distance runners, including the subjects of this study, generally have higher aerobic capacities (Jordan, 1977; Wilmore and Brown, 1974). In an extensive review of the physiological characteristics of champion female athletes, Plowman (1974) reported the  $\dot{V}O_2$  max of runners, sprinters, and cross-country skiers to average 58-60 ml.kg<sup>-1</sup> min<sup>-1</sup>, while the  $\dot{V}O_2$  max of women athletes in other sports ranged from 43 ml.kg<sup>-1</sup> min<sup>-1</sup> for gymnasts to 52 ml.kg<sup>-1</sup> min<sup>-1</sup> for swimmers. The highest value for an adult female athlete was 74 ml.kg<sup>-1</sup> min<sup>-1</sup>, attained by a woman cross-country skier (Saltin and Åstrand, 1967). The best female distance runner tested to date had a  $\dot{V}O_2$  max of 71.1 ml.kg<sup>-1</sup> min<sup>-1</sup> (Wilmore and Brown, 1974), nearly

matching that of the cross-country skier. While none of the runners in the present study approached these values, they did have  $\text{VO}_2$  max results greater than other female athletes. The novice, least trained, and least experienced runners were more nearly similar to other female athletes than were the experienced runners, suggesting that the high aerobic capacities of distance runners are associated with years of long distance training.

Slightly higher  $\text{VO}_2$  max values have been reported for women distance runners than those obtained from subjects in this experiment. Yet, the data from the present study supported the conclusion of Wilmore and Brown (1974) that women distance runners have greater aerobic capacities than the average female and most female athletes.

The potential inaccuracy of estimation of body composition by skinfold techniques has been pointed out by others (Flint, Drinkwater et al, 1977; Pollock, Gettman et al, 1977). Since the two groups (i.e. novice and experienced non-elite women marathon runners) had not been previously studied, the use of this technique was considered valuable to indicate an estimation of the body composition of these women. The implications and conclusions drawn from these data are tentative, at best, and await confirmation with more rigorous measurement techniques.

The anthropometric measures of the novice and experienced women marathon runners in the present study are similar to those reported for other women distance runners. Jordan (1977) examined selected anthropometric characteristics of eleven women who were running 32 to 145 km (20 to 90 miles) per week in preparation for various running events. Using skinfold techniques, the average body fat of these women was estimated to be 16.6%. Drinkwater, Kupprat et al (1977) hydrostatically weighed five women marathoners and reported them to be light (49.8 kg) and lean (12.5% body fat). The physique and body composition of world-class and national-calibre athletes, including 70 women distance runners were studied by Wilmore, Brown et al, 1977). The average percentage of body fat for the women runners was 16.8%. Wilmore and Brown (1974) investigated the endurance capacity and body composition of 11 highly trained female endurance athletes, although not all the women studied were marathon runners, all were considered to be outstanding athletes in long distance competition (i.e. races of 2 miles or longer); the mean percentage of body fat of these women was 15.2%.

It appears that women distance runners, regardless of their performance level, are similar in body composition. They seem to be: (a) lower in body weight and leaner than the average female, (b) lower in body weight and approximately the same in relative body fat as the

average male, and (c) lower in body weight and greater in relative body fat than male long distance runners (Wilmore and Brown, 1974; Wilmore, Brown et al, 1977). Limitations to generalisations posed by the use of skinfold techniques have not gone unrecognised.

Results of investigations of the physiological determinants of endurance running success, conducted with male subjects, have suggested that a large  $\text{VO}_2$  max, running efficiency, and the ability to utilise a large portion of one's aerobic capacity are necessary for successful performance (Costill, Branam et al, 1971; Davies and Thompson, 1979; Pollock, Gettman et al, 1977). Costill, Thomason et al (1973) reported no association between  $\text{VO}_2$  max and performance, but their subjects were quite homogeneous in aerobic capacity suggesting that a high  $\text{VO}_2$  max is essential, but does not necessarily insure success.

Significant correlations ( $r = -0.55$  and  $-0.62$ ) have been noted between  $\text{VO}_2$  max and run time for a 2 mile and a 2 km run (Katch and Henry, 1972; Stewart, Williams et al, 1977). Davies and Thompson (1979) reported a significant relationship between  $\text{VO}_2$  max and marathon finish time for men ( $r = -0.72$ ) and women ( $r = -0.43$ ) runners. In the present study, a much stronger relationship was observed between  $\text{VO}_2$  max and marathon finish time for women runners ( $r = -0.72$ ). As suggested earlier,  $\text{VO}_2$  max is not a predictor of success in a homogeneous group (Costill, Thomason et al, 1973), however, it appears that predictability is enhanced as the group has greater variability in  $\text{VO}_2$  max.

Finish times of novice (282.2 min) and experienced (226.9 min) runners were different ( $p < 0.01$ ). Since the two groups examined in this study were not different in anthropometric characteristics, the differences in  $\text{VO}_2$  max,  $\text{VE}$  max, and years of training among the groups must be associated with running success. Further study is necessary to determine the influence of each of these variables on marathon performance.

## CONCLUSION

In general, women distance runners appear to be lean and have high aerobic capacities when compared to sedentary women and other women athletes. While body composition seems to be similar for all women distance runners, aerobic capacity is quite different, with elite distance runners having the greatest  $\text{VO}_2$  max, and novices having the smallest. This suggests that for trained women distance runners, successful performance (i.e. faster race pace and finish time) is associated with a greater aerobic capacity rather than with body composition. Certainly, other factors (e.g. running efficiency and fractional use of  $\text{VO}_2$  max) are important determinants of success in a group of women runners who are homogeneous in  $\text{VO}_2$  max, but when a great disparity exists in  $\text{VO}_2$  max, performance appears to be predictable.

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## BOOK REVIEW

**Title:** COMPETITIVE PISTOL SHOOTING  
**Author:** Dr. Laslo Antal (British National Coach)  
**Publisher:** EP Publishing Limited, UK, 1983, ISBN 0 7158 0787 0  
 Price: £6.95 176 pages

Laslo Antal's earlier book, *Know the Game* (EP Publishing Limited) introduced the tyro to the basic techniques used in small bore pistol and air pistol shooting.

The present book covers the ground from these basics up to the advanced techniques used in international competition.

The book is in five parts. Part 1 covers all the basic principles and equipment. It starts appropriately with a chapter on safety, a theme that is emphasised throughout the book. Part 2 covers the various types of competitive shooting in the UIT disciplines, namely Free Pistol, Rapid Fire Pistol, Centre Fire and Ladies' Match, Standard Pistol and Air Pistol. Throughout these chapters and indeed throughout the book there is much emphasis made on the importance of training as an aid to eliminate errors in basic technique. Furthermore the analysis and correction of errors is admirably dealt with.

In Part 3 the author introduces the reader to other types of pistol shooting that are less well known such as Practical Pistol, Long Range Pistol, Muzzle Loading and Percussion Pistol. This section ends with a chapter on Hand Loading of centre fire pistol cartridges, an important aspect of this form of shooting due to the high cost nowadays of factory ammunition.

Part 4 deals with the Anatomy, Physiology and Psychology of shooting in language and diagrams that are easily understood by the layman. All technical and medical terms are defined in a comprehensive glossary at the end of the book.

Finally, in Part 5, the mental and physical aspects of training are covered in great detail.

Dr. Antal is to be congratulated on writing a most comprehensive book that is a model of clarity and accuracy. It is profusely illustrated on high quality paper with excellent photographs and line diagrams and deserves to become the standard reference work in its field.

B. C. Lewis